**CONCEPT PRESENTATION C SUMMARY**

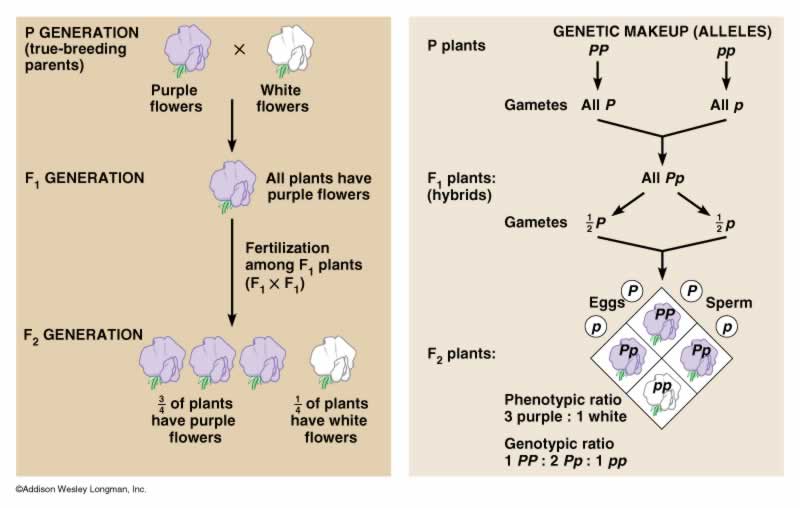
**Solving Genetic Problems (Punnett Squares)- Grade 11 University Preparation**

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**Background Information- Punnett Squares**

A Punnett square is a diagram used to illustrate the types of gametes produced as well as the genetic combinations that might occur at fertilization of those gametes. It was first introduced by a British mathematician Reginald Punnett in 1906, and is used extensively to determine the likelihood (ie. probability) that a certain genetic event will occur.

Punnett squares are used to depict monohybrid crosses and dihybrid crosses. A monohybrid cross is a cross between hybrids of a single trait. It illustrates Mendel’s law of segregation, which states that two alleles of a single trait segregate during gamete formation, then randomly unite, one from each parent, at fertilization. For example, when crossing homozygous dominant purple (PP) flowered plant with homozygous recessive white (pp) flowered plant, the purple parent donates gametes with only P alleles and the white parent donates gametes with only p alleles, resulting in F1 progeny that are hybrids (or heterozygous Pp) and are all identical. Crossing a male and female from the F1 progeny is called a monohybrid cross, as the male and female have hybrid genotypes, and we are crossing only a single trait, colour of flowers. The male can donate either P or p gametes and the female can donate either P or p gametes, so the resultant F2 generation, the progeny of the F1 hybrids, has a phenotypic ratio of 3 purple: 1 white and a genotypic ratio of 1PP: 2Pp : 1pp. From a probability perspective, the probability of the F2 progeny having purple flowers is ¾ or 75%, while the probability of white flowers is ¼ or 25%.

 **FIGURE 1: Monohybrid Cross** (2)

Dihybrid crosses work in much the same way, but this time hyrbrids of two traits are being crossed, resulting in a 9:3:3:1 ratio phenotypic ratio. Dihybrid crosses illustrates Mendel’s law of independent assortment, which states the alleles of different traits segregate or assort independently of one another.

Monohybrid crosses and dihybrid crosses are good examples to introduce the solving of genetic problems using Punnett squares. When solving a genetic problem, first make sure to read the question thoroughly and list the information supplied to you. Write down the genotypes and phenotypes of the parents or offspring depending on what is given, assign symbols for the alleles and indicate the genotypes. Draw diagram and set up Punnett squares to help solve the problem.

**Example:** Fruit flies have dominant alleles for normal wings, T, and recessive alleles for tiny wings, t, as well as dominant alleles for normal, oval eyes, N, and recessive alleles for narrow eyes, n. A female fruit fly that is heterozygous for wing size and homozygous recessive for eye shape is mated with a male fruit fly that is heterozygous for wing size and homozygous for eye shape. What is the probability that their offspring will have normal phenotypes for both traits? (1)

Female fruit fly genotype: Tt nn

Male fruit fly genotype: Tt Nn

Female fruit fly donate the following alleles: T, t and n

Male fruit fly donate the following alleles: T, t, N and n

Punnett square:

|  |  |  |
| --- | --- | --- |
| X | FEMALE ALLELES | |
| MALE ALLES | **T n** | **t n** |
| **T N** | TT Nn | Tt Nn |
| **T n** | TT nn | Tt nn |
| **t N** | Tt Nn | tt Nn |
| **t n** | Tt nn | tt nn |

There is a total of 4 possible phenotypes for F1:

- Normal wings, normal eyes

* Normal wings, narrow eyes
* Tiny wings, normal eyes
* Tiny wings, narrow eyes

The phenotypic ratio for this cross is:

3 normal wings, normal eyes : 3 normal wings, narrow eyes: 1 tiny wings, normal eyes: 1 tiny wings, narrow eyes (3:3:1:1)

Therefore, the probability that the progeny will have normal wings and normal eyes is 3/8 or 37.5%.

**Advance Preparation**

Prior to learning about Punnett Squares and to solving genetic problems, students would have to be familiar with the differences between genotype and phenotype; DNA, genes and alleles; recessive, dominant, codominant and incomplete dominant traits; and heterozygous and homozygous traits. Students would also have to thoroughly understand the Mendelian laws: the law of segregation and the law of independent assortment, and how Mendel came to the discovery of these laws. Students must be familiar with the concepts of artificial selection, hybrids, parental (P) generation and filial generations (F1, F2 etc.), monohybrid and dihybrid crosses, and sex-linked traits as well as a general understanding of meiosis, gamete formation and fertilization.

For the mathematics involved with Punnett squares, students must have a basic understanding of probability and binomial distributions.

**Teaching Ideas**

We needed to transmit the knowledge of mathematics and genetics by targeting students of different learning styles:

* Logical/Mathematical: worksheets and probability exercises
* Linguistic: Debates, research, and class discussions as well as reflection papers
* Bodily kinesthetic: Role-play with alleles in the gym.
* Visual/Spatial: Gizmos lab

**Curriculum Expectations**

These lessons will fulfill the following curriculum expectations:

D2.3 use the Punnett square method to solve basic genetics problems involving monohybrid crosses, incomplete dominance, codominance, dihybrid crosses, and sex-linked genes

D3.3 explain the concepts of genotype, phenotype, dominance, incomplete dominance,

codominance, recessiveness, and sex linkage according to Mendelian laws of inheritance

**Lesson Sequence**

Several lessons will be required for students to fully understand genetics and genetic problems. Here is a suggested sequence of progressive lessons that will help prepare students for solving genetic problems:

* **Lesson One:** Genotype Vs. Phenotype.
* **Lesson Two:** DNA and Alleles.
* **Lesson Three:** Recessiveness and dominance.
* **Lesson Four:** Mendelian Laws.
* **Lesson Five:** monohybrid crosses, dihybrid crosses, and sex-linked genes.
* **Lesson Six:** Solving Genetic problems with Punnett squares.

**Potential Student Difficulties and Solutions**

The main problem we foresee students having is with the mathematics involved with Punnett Squares, specifically probabilities and binomial distributions. Students will need to apply the Mendelian laws and determine probabilities to make predictions on the genotypes and/or phenotypes of the progeny. One method that may help overcome this difficulty is to spend a period reviewing these math concepts, as well as working through various applicable probability problems to clarify the methodology, including tips and tricks. These problems do not have to be genetics-based, but can be any typical probability problem, like rolling dice, drawing playing cards etc.

Another problem students may have is understanding the notions of alleles, loci and genes, as they all can be conceived as somewhat similar. An allele is the various alternate forms of a single gene, and that single gene can have many alleles. A locus, on the other hand, is any specific location on a chromosome. We think the suggested Alleles Gizmos Lab and the Alleles Role Play may help clarify these differences as well as clarify various other questions about alleles and genes that may arise.

Lastly, students may have problems distinguishing between the Mendelian laws: the law of segregation and the law of independent assortment. These two laws are quite similar, but define different ideas. The law of segregation states that two alleles of a single trait segregate during gamete formation and then one allele from each parent randomly unite at fertilization, while the law of independent assortment states that different pairs of alleles segregate independently of each other. Again, we suggest the Alleles Gizmos Lab and the Alleles Role Play along with clear definitions and examples to help clarify any misunderstandings.

**Differentiated Assessment**

Throughout the progressive lessons regarding genetic problems, various forms of assessment will be applied to determine the level of student understanding. Prior to introducing Punnett Squares, a diagnostic quiz will be administered testing student knowledge in probability and probability problems. This will help gauge how much time, as a class, must be spent reviewing probability methodology. Formative assessments will also be administered. The students will be expected to hand in the Student Exploration Worksheet associated with the Alleles Gizmos Lab, which will be marked for Knowledge and Understanding, and Thinking and Inquiry. Also, students will be assessed during the Allele Role Play activity for Knowledge and Understanding as well as Communication. Furthermore, students will write one or two quizzes assessing the progress of their understanding, including definitions, Punnett squares and genetic problems. Finally, students will be assessed daily on their oral responses during in class discussions. For summative assessment, students will write a genetics unit test which will assess all the learning skills and will include various definitions and the solving of various genetic problems.

**Annotated References**

1. Hartwell et al.(2008). Genetics: From Genes to Genomes. McGraw-Hill, New York.

This book was used primarily as a source of background information on Mendelian genetics, probability, Punnett squares and solving genetic problems. Although the material presented in this textbook may be a bit advanced for grade 11 students, it is an excellent resource to refresh a teacher’s understanding of genetics, as well as offers some excellent, genetics related discussion topics.

1. Pitochelli, Jay. (2001). “ Lecture Notes for Genetics”. Retrieved November 7, 2011 from <http://www.anselm.edu/homepage/jpitocch/genbio/geneticsnot.html>.

This site too was used primarily as background information. Also, FIGURE 1 was retrieved

from this site.

I found these websites useful:

1. **Practical applications of genetics in medicine and surgery**. <http://www.ncbi.nlm.nih.gov/pmc/articles/PMC1817215/pdf/brmedj02576-0029.pdf>
2. **Medical applications**

<http://www.biophage.com/genetic-engineering.html>

1. **Disease diagnosis and prevention through genetic technology:** <http://www.michener.ca/ce/postdiploma/genetics_technology.php#what>